Exciton Landé g-factor measurement in TMDCs with very low magnetic fields

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Mono-/few-layer transition metal dichalcogenides (TMDC), of the form MX_2 (M=W, Mo, Re and X=S, Se, Te), can exist as stable quasi two-dimensional semiconductors. In their optical spectra one observes several exciton and related many-body excitation resonances such as trions, bi-excitons etc. These are influenced by novel spin related phenomena in these materials such as spin-valley coupling, spin-layer locking, spin-pairing dependent formation of dark excitons etc. Origins of some of these resonances have been debated. The study of excitons under magnetic fields and measurement of their Landé g-factor (LGF), enables identification of their band origins and also new properties such as Berry curvature related valley angular momentum associated with these materials.

We have measured the LGF of excitons in bulk TMDC semiconductors using two magneto-optical techniques that use principles of modulation spectroscopy. Conventional exciton LGF measurements in TMDCs typically require high, tens of tesla, magnetic fields. We established a technique, that of magneto-modulated reflectance (MMR) spectroscopy, which enabled LGF measurement with very low oscillating magnetic fields of the order of 50mT rms [1]. Thereafter to improve sensitivity of LGF measurements we built a setup for magneto-optical Kerr effect (μ-MOKE) spectroscopy that used fields up to 2T [2]. These setups provide tens of micrometer spatial resolution, required for studying microscopic flakes of TMDCs, at cryogenic temperatures. Their working was analyzed using Jones matrix approach and the authenticity of the measured spectra was tested using Kramers-Kronig analysis.

The existence of an inter-layer (IL) exciton state had earlier been shown in few layer 2H-MoS_2. Our measurement of LGF using MMR and μ-MOKE spectroscopy helped confirm the presence of the IL_A exciton state, adjacent to the ground state A-exciton in bulk 2H-MoS_2 [1,3]. In addition, the high sensitivity of the μ- MOKE spectroscopy setup helped us discover a new theoretically predicted IL_B exciton species, associated with the higher energy spin-orbit split B-exciton in 2H-MoS_2 [3]. We also address the issue of low LGF magnitude of the IL_A exciton in 2H-$MoSe_2$ and 2H-$MoTe_2$. The experimental results were analyzed using a simple additive model for LGF invoking the Berry curvature related valley angular momentum and were also compared with ab-initio calculations based on density functional.

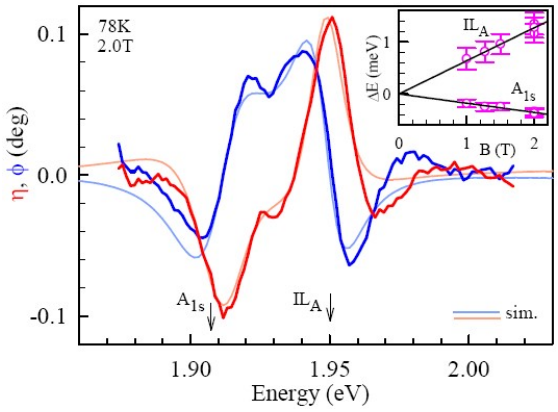

Figure 1: Measured and simulated MOKE ellipticity (η) and rotation (ϕ) spectrum of 2H-MoS_2 around the A-exciton transition. Inset shows the variation of exciton Zeeman splitting with applied magnetic field.

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References

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